

Electron-Beam Therapy in the Treatment of Carcinoma of the Penis

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The utility of radiation therapy by the high energy electron beam, especially of 12 MeV energy, generated from the Linear Accelerator has been studied through the dose distributions in the penis phantoms and case results of 6 patients with the carcinoma of penis.

The application of local external irradiation accompanied with the regional lymph nodes' irradiation may acquire fairly good results with long term survival, even for the patients on the stages III-IV.

INTRODUCTION

As the result of Betatron and Linear Accelerator have been come into wide use of medical field, the irradiation of electron beam radiated from these generators have been preferably applied to the radiation therapy on the treatment of various kinds of superficial tumor including skin cancers and subcutaneous tumors.

There are many indications recently that the radiation therapy by means of small radiation source, especially on the intracavity therapy to the oral cavity, tongue, uterine cervix and the like, has been replaced with the irradiation of high energy electron beam.

However, it seems that regarding the radiation therapy on the treatment of carcinoma of the penis, the presentations of paper concerning about the technique utilized the irradiation of X-ray (EDSMYR²⁾ and EKSTRÖM 1960, ETO¹⁾ et al. 1967, MARCIAL⁵⁾ et coll. 1962, MURPHY⁶⁾ 1967, MIYAKAWA⁷⁾ et al. 1969, NEWAISHY⁸⁾ and DEELEY 1968) and of γ -ray from the telecobalt unit (KOPPENFELS⁴⁾ and FONFARA 1973) are rather many in comparison with these of electron beam irradiation (KOPPENFELS⁴⁾ and FONFARA 1973).

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From a social and philosophical point of view, which looks upon the penis as a symbolical organ for male, we consider that the amputation should be applied to the patient as just last of all measures of treatment for the affected penis, in order to preserve its function as well as the substance. Whilst, we believe that the irradiation of X-ray or γ -ray should be always applied to the regional lymph nodes.

If the radiation treatment on the affected part will indicate an equivalent survival rate with the surgical procedure to the part, it should be naturally chosen as the adoptable measure.

In this report, the author will describe that in the local external irradiation to the carcinoma of penis, the high energy electron beam irradiation is superior to the complicated mould therapy of using X-ray or γ -ray (FLETCHER³⁾ 1973, MURPHY⁶⁾ 1967, NEWAISHY⁸⁾ and DEELEY 1968), and also the application of this technique for the patients and accompanied advantages deserve more attention.

METHOD

Penis Phantom

The author have made the phantom of penis with adult standard size of two Mix-Dp plates of 2.5 cm thickness. This phantom is shown in Fig. 1 (left side). The longitudinal axis of this phantom corresponds to the longitudinal axis of penis. This phantom will be used to take a picture of dose distribution on the longitudinal section of penis. Furthermore, another cylindrical phantom has been made of two plates of same material and thickness. This phantom is shown at the right side in Fig. 1. The columnar part corresponds to a part of penis cut out axial transversally. This will be used to take a picture of dose distribution on the axial transversal section of the penis. The longitudinal axis of each phantom is on the joint section of two Mix-Dp plates. All joint surfaces of these phantoms have been finished to the smooth surface, in order to insert the X-ray film. These phantoms will be divided in the middle (joint section), respectively, and then all half sections of these will be fitted to the two phantom-holders of Mix-Dp plate of 2.5 cm thickness, as shown in Fig. 2. These phantoms will take their original forms when the phantom holders will be put properly together (Fig. 1).

The picture of dose distribution in the phantoms may be taken longitudinally or axial transversally on the film inserted into the joint section of phantom--holders including the joint sections of these phantoms.

Sensitive Material

The author have used the X-ray films, KODAK MO-type for industrial use, without any intensifying screen.

Toshiba Colour-Dotted Film Density Plotter-Model MRA-201-3 (SHIGEMATSU¹⁰⁾ and MAKINO 1968)

The X-ray film, exposed to the radiation with same condition as the radiation

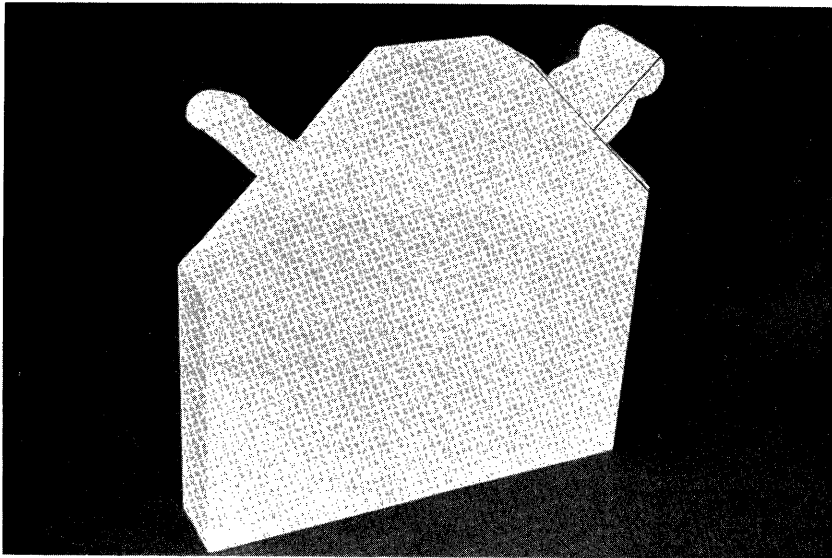


Fig. 1 Picture of phantoms with phantom holder.

Left : the phantom which is used to take the dose distribution on the longitudinal section, when it is longitudinally covered by a cone.

Right : the phantom which is used to take the dose distribution on the axial transversal section, when the cone (or cones) is (or are) set perpendicularly to its longitudinal axis.

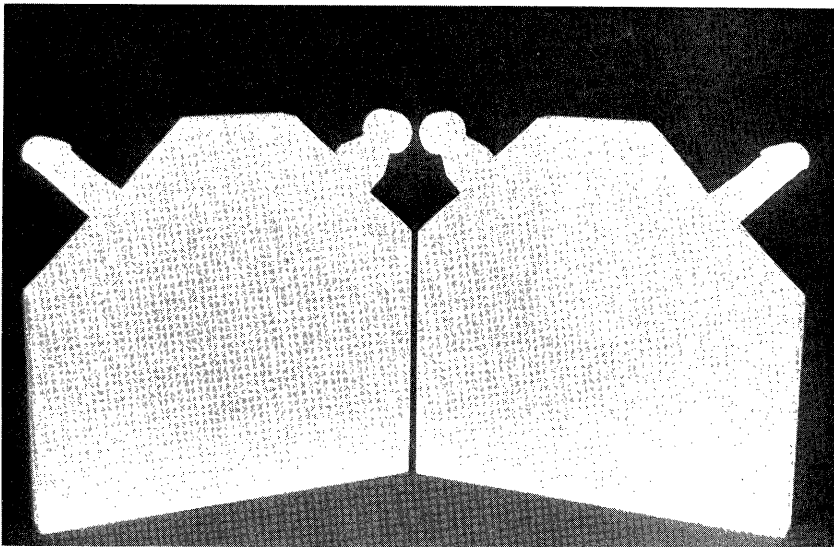


Fig. 2 Phantoms and phantom holder opened at the joint surfaces, in order to insert the X-ray film.

treatment of penis, will be developed together with the reference film, irradiated with a known radiation dose. Then, the distribution of isodensity curves on the film developed will be measured photometrically by means of the scanning photosensor (photomultiplier) method. Then, the picked-up signals will be in process of the 10-channel pulse height analyzer and finally will be plotted on the X-Y plotter as the map of density distribution with the 5 isodensity-curves classified by the 5 different colour felt sign pens.

The indications have been set as 100% at the highest density area and 0% at the base-sheet of film.

Irradiation Technique

The high energy electron beam has been generated by the Toshiba 13 MeV Linear Accelerator, LINAC Model LMR-13 (OZEKI⁹⁾ et coll. 1969). Following two irradiation techniques have been adopted.

(1) The penis has been longitudinally covered to 5 cm length from the top of glans by the cone with 4 cm diameter, and then irradiated by the electron beam from the single field radiation of 6 MeV or 12 MeV, under the condition of radiation dose of 30R, more or less.

(2) The $4 \times 8 \text{ cm}^2$ cone has been set perpendicularly to the longitudinal axis of penis (cylindrical phantom) as shown in Fig. 5, and then the penis (phantom) has been irradiated with same condition as mentioned in item (1). Furthermore, the three-field irradiation of the electron beam with the energy of 6 MeV or 12 MeV has been applied to the penis (cylindrical phantom) under the irradiation condition of 30R total. In this case, $4 \times 8 \text{ cm}^2$ cones have been set perpendicularly to the longitudinal axis of penis at 90° intervals, as shown in Fig. 7.

RESULTS

In the Case of Penis Longitudinally Covered by Cone

When the penis is in the state of no erection, this will be most recommendable measure, since the fixing of penis may be easily done.

Almost all of 80% effective radiation dose region have been included in the axial transversal section of penis at 3 cm depth from the top of glans in the case of 6 MeV irradiation, and also in the axial transversal section at the depth not exceeding 5 cm in the case of 12 MeV irradiation. Accordingly, these technique should not be applied to the larger figure of depth than above, since the radiation dose will be insufficient. The available depth of radiation beam will depend on the length of transmissible passage of the electron beam corresponds to the maximum accelerating energy, which will be naturally limited by the performance of apparatus used. In the case of the LMR-13, the electron beam irradiation will be effective to the region of 5 cm depth and less longitudinally from the top of glans.

In this irradiation technique, a lead plate of 5 mm thickness should be set at the radix of penis, in order to shelter the scrotum from the electron beam (of 10%-60% dose) which is radiated through the space between the cone and penis (see Fig. 3 and Fig. 4).

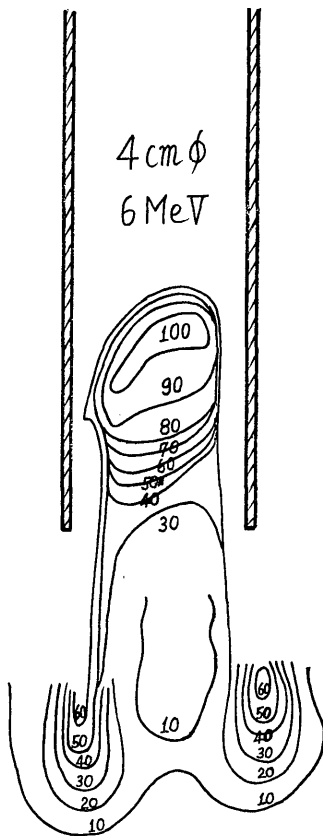


Fig. 3 Dose distribution on the section including the longitudinal axis of penis phantom : 4 cm diameter cone and 6 MeV electron beam irradiation.

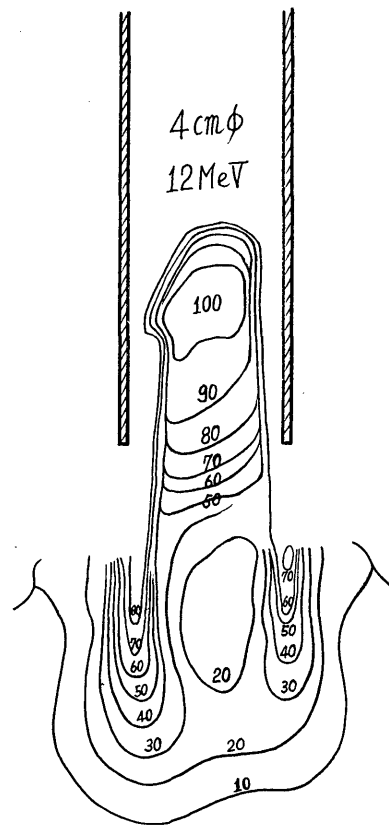
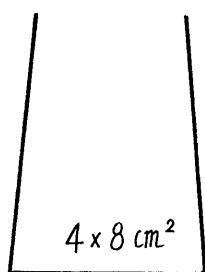


Fig. 4 Same technique as Fig. 3, except irradiation condition of 12 MeV.

In the Case of Cone set Perpendicularly to Longitudinal Axis of Penis

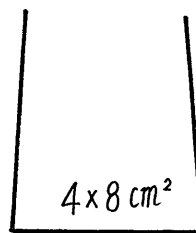
In case of this measure, the box made of polystyrene plates should be set between patient's both femurs, and then the patient's penis should be fixed at the top of box by any adhesive plaster. The dimension of cone should be selected so that the region of carcinoma can be entirely included inside of the radiant flux. The single field irradiation with 6 MeV energy is not suitable for this irradiation technique, for the extent of 80% effective radiation dose is not so large that it will be able to include the whole of circumscription of penis. Besides, the radiation dose distribution in this case is not uniform inside of the circumscription of penis as shown in Fig. 5. However, the same technique with 12 MeV energy may yield preferable distribution with uniformity for the most part of inside of the circumscription of penis as shown in Fig. 6.

In the case of three-field irradiation of 6 MeV energy, the extent of 100% dose may be narrower than the extent of single field one of 12 MeV, as shown in Fig. 7. It seems that three-field irradiation of 12 MeV energy is most recommendable measure for this therapeutic purpose, as shown in Fig. 8. In this case, the lead protection plate for the



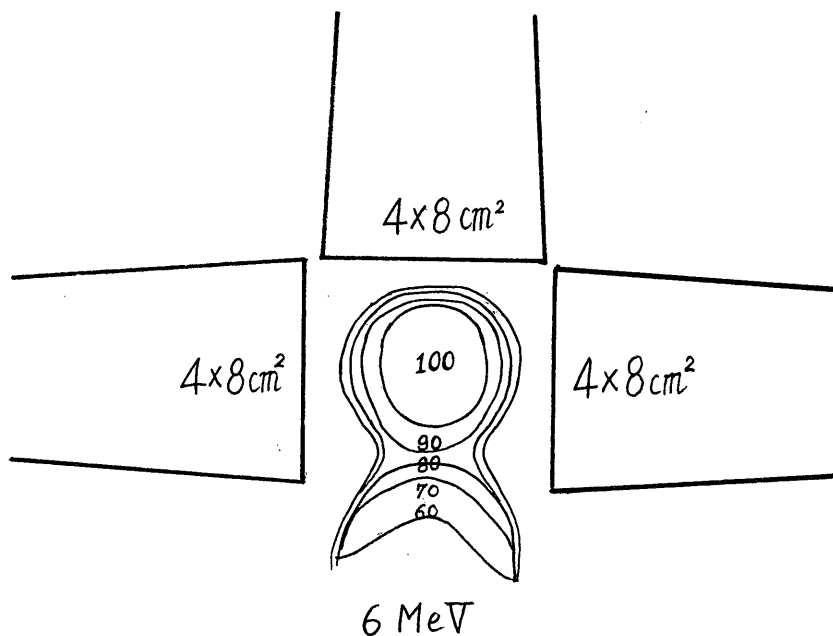
6 MeV

Fig. 5 Dose distribution on the axial transversal section of the cylindrical phantom: single field irradiation, with $4 \times 8 \text{ cm}^2$ cone and 6 MeV electron beam irradiation.



12 MeV

Fig. 6 Same technique as Fig. 5, except irradiation condition of 12 MeV.



6 MeV

Fig. 7 Dose distribution on the axial transversal section of the cylindrical phantom: three-field irradiation with $4 \times 8 \text{ cm}^2$ cones and 6 MeV electron beam irradiation.

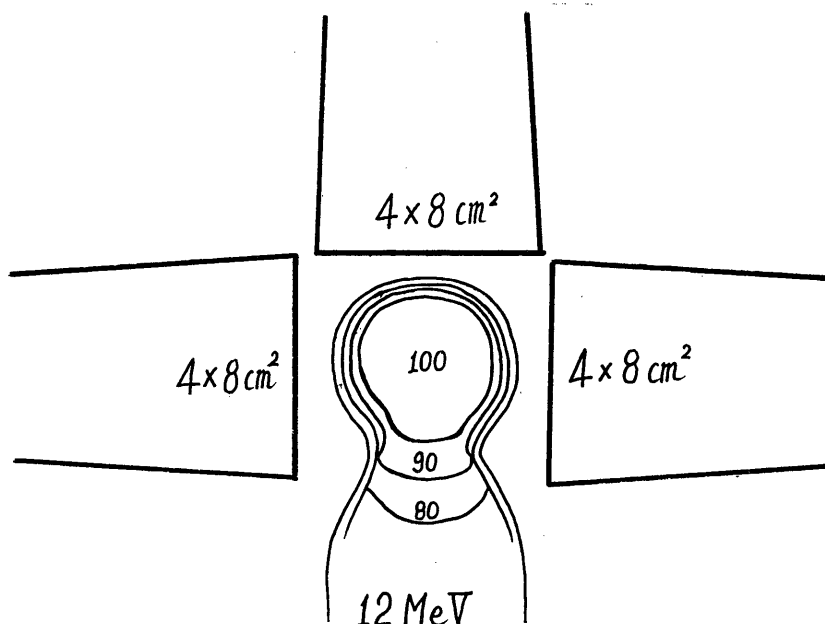


Fig. 8 Same technique as Fig. 7, except irradiation condition of 12 MeV.

radix of penis may be unnecessary, since no irradiation in this position.

Accordingly, the machines which will generate the radiation of electron beam with maximum 13 MeV energy, like as the Model LMR-13, are quite suitable for the purpose of these irradiation techniques.

CASE REPORTS

S. K. 61 years old, male, office clerk.

He was born with the phimosis. In June 1970, he found that his foreskin of penis was swelled and the secretion came out from the swelling part. Then, the phimosectomy was applied to his affected part. Consequently, the tumor of $39 \times 29 \times (30)$ mm size was observed at his glans of penis, and then it was diagnosed as the squamous cell carcinoma through the biopsy examination. Then, the treatment procedure has been shifted immediately to the i. v. injection of the 15 mg Bleomycin at regular intervals of every two days, and the total quantity 450 mg was applied to him through nearly two months. Nevertheless, the carcinoma has not been scarcely shrunk with these procedures. Then, the patient has been transferred to the radiology department from the urology's. (Fig. 9)

From the 21st Dec. 1970 to the 14th Jan. 1971, the four-field irradiation of electron beam of 12 MeV energy with the cone of 6×8 cm² size was applied to the glans of penis in the radiation rate of 300 rad/day/field, that is, the total tumor dose of 5,100 rad. was applied to the focus. The tumor shrunk nearly half size with 3,000 rad. irradiation,



Fig. 9 Grans of pens before starting of radiation therapy.

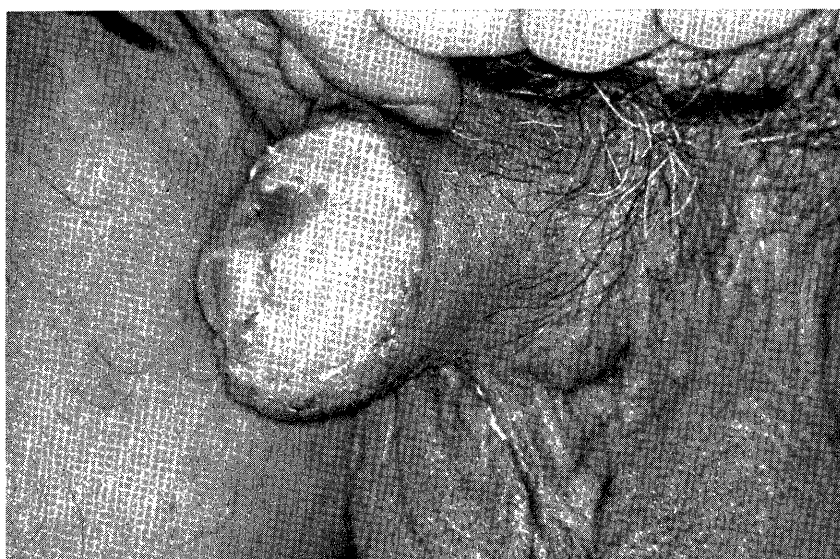


Fig. 10 Grans of penis after application of radiation therapy with following procedures :

12 MeV electron beam.

four-field irradiation with 6×8 cm² cones, 300 rad $\times 17 = 5,100$ rad.

and then almost all of it was vanished with 5,000 rad.. This position was covered with the fur coat and bred some erosion partially as the result of irradiation. At that moment, the biopsy examination proved the existence of granulomatous change resulted from the treatment of focus. Furthermore, the result of biopsy examination on the inguinal lymph nodes verified no metastasis there. However, the application of preventative irradiation for the true pelvic cavity including the inguinal lymph nodes was commenced with following conditions on 25th Feb. 1971;

energy:	10 MV X-ray
irradiation field size:	$22 \times 22\text{cm}^2$
irradiation technique:	anterior and posterior opposing 2 - field
irradiation dose:	$100\text{R} \times 2 = 200\text{R}$ $150\text{R} \times 4 = 600\text{R}$ $200\text{R} \times 21 = 4,200\text{R}$
	<hr/> total = 5,000R

Then, he has left the hospital, and afterwards was in fairly good health, though the slight edema of his bilateral lower extremities was still observed. However, in the September 1974, the recurrence of red colored carcinoma of $24 \times 34 \times 24\text{ mm}$ size, accompanied with raw and papillomatous state, was observed on his glans of penis. Then, the electron beam irradiation with the following conditions was applied to the carcinoma recurred:

energy:	12 MeV electron beam
cone with 4 cm dia.:	longitudinally covered the carcinoma (on glans of penis)
total penile dose:	5,100 rad. (300 rad \times 17 days)

The carcinoma shrunk to the $24 \times 24 \times 4\text{ mm}$ size at the sum of irradiation dose of 1,500 rad., to the $23 \times 16 \times 4\text{ mm}$ size at the 3,000 rad., and finally vanished entirely at the 5,100 rad. (Fig. 10) The swelling on his scrotal skin caused by the radiation edema is still observed, but he is still (as of June 1976) in good health without any recurrence, after the lapse of five years and five months since the first irradiation.

The author applied the irradiation technique of high energy electron beam to the treatment of carcinoma of the penis of other 5 patients between 1970 year and 1974, and obtained the results of three cases of the survival of more than two years (one of them is the survival of two years and two months), one case of the survival of 17 months and another one case of the death after 8 months.

DISCUSSION

There are many reports to the effect that the phimosis may be the cause of carcinoma of penis (ETO¹⁾ et al. 1967, FLETCHER³⁾ 1973, MIYAKAWA⁷⁾ et al. 1969) and the cases in

this report were in similar situation, as well. It seems that the aged people have rather high occurrence rate for the carcinoma of penis. For the 6 cases in this report, the lowest age was 46 years old and the highest one was 70 years old, and the average age was 60.5 years old.

KOPPENFELS⁴⁾ and FONFARA(1973) have reported that they had applied the surgical procedure or radiation therapy to the carcinoma of penis of 63 patients for 24 years and also EDSMYR²⁾ and EKSTRÖM(1960) have reported that they had treated 229 patients of the similar cases by means of the surgical procedure or radiation therapy for 35 years. It seems that the carcinoma of penis did not show so large occurrence figure in comparison with the malignant tumors on the other organs. Similarly, the author has been experienced that only 6 cases (0.46%) among of the total 1,296 cases, which were treated with radiation therapy for last 5 years, were of the carcinoma of penis, and all of these cases were the squamous cell carcinoma.

It has been reported that the keratinized squamous cell carcinomas on the stages I and II had had the high radiation sensitivity (KOPPENFELS⁴⁾ and FONFARA 1973) and the survival rats of 5 years on similar cases had showed the excellent figure of more than 70% ~ 80% (ETO¹⁾ et al. 1967).

In the total 6 cases of patients on the stages III – IV which have been treated by the author, the existence of metastasis has been verified in the lung on one case and also in the lymph nodes on five cases. The survival rates for above 6 cases were 5/6 on one year, 4/5 on two years, 3/4 on three years, 1/3 on four years and 1/1 on five years.

The local external irradiation techniques reported in the past have covered the following measures;

- (1) 45 kVp X-ray contact therapy (EDSMYR²⁾ and EKSTRÖM 1960, MURPHY⁶⁾ 1967).
- (2) 100–200 kVp X-ray radiation therapy (MURPHY⁶⁾ 1967, NEWAISHY and DEELEY⁸⁾ 1968).
- (3) Mould therapy with the small radiation source of Ra or ⁶⁰Co (FLETCHER³⁾ 1973, MURPHY⁶⁾ 1967, NEWAISHY⁸⁾ and DEELEY 1968).
- (4) Tele-Cobalt therapy (FLETCHER³⁾ 1973, KOPPENFELS and FONFARA 1973).

However, it seems that the reports on the electron beam irradiation by means of the Betatron or Linear Accelerator are rather few. (KOPPENFELS⁴⁾ and FONFARA 1973).

Hence the author has described the availability of using high energy electron beam, especially generated from the Linear Accelerator, with some explanatory diagrams. The local external irradiation by this generator has been preferably chosen by us for the treatment of carcinoma of penis, for this may easily yield a sufficient tumor dose and satisfactory dose distribution.

CONCLUSION

As exemplified with the case results of local external irradiation on the carcinoma of penis (squamous cell carcinoma) by means of the 13 MeV Linear Accelerator, the electron beam irradiation of high energy, especially of 12 MeV, showed the excellent availability on these patients.

The author applied the radiation therapy with 12 MeV energy to the 6 patients of the carcinoma of penis (including one patient irradiated by X-ray), which were introduced to our radiology department between 1970 and 1974. These results will indicate the following advantages;

(1) Regarding the local external irradiation by means of the LINAC (Linear Accelerator) Electron Beam, 12 MeV energy is most and superior and recommendable for the purpose of treatment of the carcinoma of penis, by reasons of the satisfactory dose distribution and facility of protection procedure for the circumference of focus.

(2) The application of the local external irradiation to the focus, accompanied with the irradiation to the regional lymph nodes, may acquire fairly good results with long term survival of more than five years, even for patients on the stages III-IV.

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